Estimating Uncertainty in Wildlife Population Estimates

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Abstract

Estimating an index of animal population size from simple counts can be very challenging. If indices are to be compared among years to assess trend there must be some consistency in what fraction of the population the index is measuring. Variation in population indices among years may be due to variation in the size of the population but it may also be due to variation in counting procedure, in animal detection and, for migratory and foraging animals, in the proportion of the total population available to be counted.

We discuss two case-studies of animal counts where we attempt to quantify this extra variation, or uncertainty, using Monte Carlo simulation. In the first case-study we assess uncertainty in penguin population indices from counts, and in the second, we assess uncertainty in migratory bird counts from braided rivers in New Zealand.

Understanding Uncertainty

Uncertainty arises from:

- Observer variation, different observers get different counts,
- Measurement variation, not all animals that are at a location at a given time can be observed and counted,
- Temporal variation, variation in the number of animals that are available to be counted among phases in the breeding cycle in a given year,
- Spatial variation, variation in size among sub-populations at different sites,
- Temporal-spatial variation, variation in timing of breeding-phases among sub-populations at different sites in the breeding cycle,
- Inter-annual variation, variation in timing of the breeding-phases among years.

And over and above this is … **changes in the population size** … what we are interested in!

Source: Kerry Weston

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Estimating Uncertainty

To estimate uncertainty using a Monte Carlo approach distributions that reflect likely levels of variation are defined. Random variates are selected from these distributions to mimic estimates of population counts. This process is repeated multiple times.

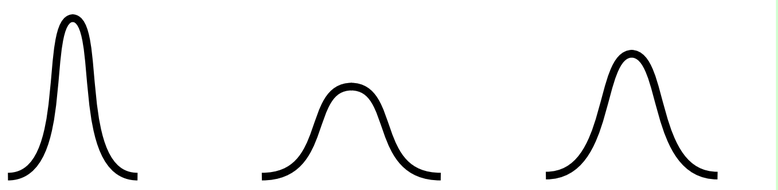
The distribution of the estimated Monte Carlo counts is used to describe the likely variation, or uncertainty in observed counts.

Estimating Uncertainty in Penguin Counts

Within a given year at a given site uncertainty in the count is from:

- Observer variation,
- Measurement variation,
- Temporal variation among breeding-phases within the year.

Different counting methods can give different distributions depending on the observer, site access, terrain and how easy it is to observe the penguins.



Temporal variation among phases of the breeding cycle means that at times almost all the population is on shore, while at other times only juveniles, or juveniles and one parent are on shore. Estimating the correct chronological time of the count within a breeding phase introduces extra uncertainty. In this application the uncertainty from the counting method was multiplied with the uncertainty from estimating the breeding-phase when the count was taken.

When there are multiple counts within a given year at a given site, each count can be estimated. The average of these is used as the estimate of abundance. The Monte Carlo process is repeated multiple times to estimate uncertainty.

Estimating Uncertainty in Bird Surveys

Within a given year in a given river uncertainty in the count is from:

- Observer variation,
- Measurement variation,
- Temporal variation among hours within a day, and among days within the season,
- Spatial variation among sites within the river.

A Monte Carlo approach can be used where random variates are drawn from each distribution. In this application the primary interest was in estimating uncertainty in the trend estimates over ten years of surveys.

Monte Carlo simulations for each of ten years were run, to estimate a distribution of possible annual counts. A random count from these distributions was selected from each year of the survey and a regression line was fitted. This was repeated multiple times, and the distribution of slope-estimates used as the estimate of uncertainty for detecting a linear trend.

Source: Jack Van Hal

Conclusion

In both these applications, Monte Carlo simulation was a very useful way to estimate uncertainty.

In the penguin and river bird examples there were limited data because counts were infrequent (for very understandable logistical reasons), and rarely surveys were repeated within a season. If the raw data had been used to estimate uncertainty the estimate would have been too low.

This method has the advantage of producing a reasonable estimate of uncertainty, although unfortunately one that managers may not want to hear!

The other advantage is that the process of indentifying the sources of uncertainty, and by conducting an intuitively straightforward assessment, means managers can assess the different survey designs and the cumulative effect of uncertainty.

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